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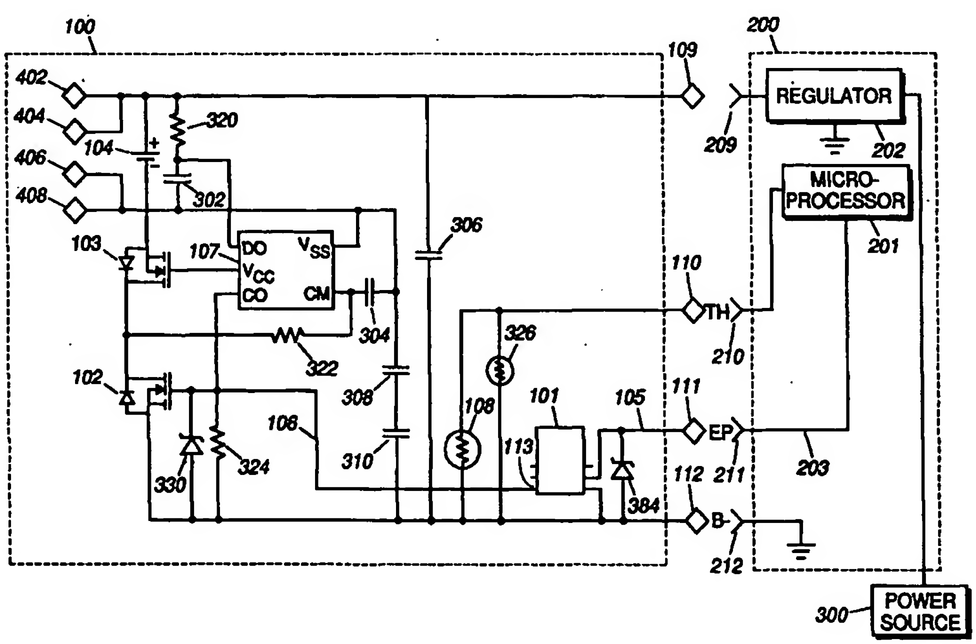


(57) Abstract

A battery charging system having bi–directional lock–out circuitry includes a battery (100) that stores an authentication code and that includes cells (104) for providing a voltage at external terminals (109, 112). A charger (200) instructs the battery (100) to connect the cells (104) to the external terminals (109, 112) in response to verifying the authentication code.

BATTERY CHARGING SYSTEM HAVING LOCK-OUT CIRCUITRY

Technical Field

This invention relates in general to batteries and chargers, and more specifically to batteries and chargers that include safety circuitry.

Background

Rechargeable, or secondary batteries, are manufactured using many different technologies. For instance, such batteries include nickel metal hydride batteries, nickel cadmium batteries, and lithium ion batteries, to name a few. Lithium ion batteries require special charging methods that control cell voltage within certain safe limits. Exceeding the voltage limits of the cell can create a safety hazard since overcharging can result in fire or explosion. Despite safety concerns, lithium ion batteries are preferred in many applications due to their high energy densities and low weights.

Lithium ion cells are typically packaged in protective housings that usually contain safety circuitry for monitoring cell voltage, preventing overcharging of the cells, and limiting cell discharge below voltages that could damage the cells or diminish battery performance. Generally, chargers specifically designed to charge lithium ion batteries are also equipped with safety circuitry to designed to safely charge lithium ion batteries. However, since the charger and battery circuits are usually enclosed within the housing and not visible to the user, the user could inadvertently charge a lithium ion battery with an incorrect charger or with a charger that does not include the appropriate safety circuits. Furthermore, the user could attempt to charge a lithium ion battery that lacks safety circuit. In either case, the absence of safety circuitry in the charger or the battery can result in the hazardous overcharging of the battery or discharging of the battery below a safe voltage.

Thus, what is needed is a device to ensure that both a lithium ion battery and its charger include safety circuitry necessary to safely charge the battery.

Brief Description of the Drawing

FIG. 1 is an electrical schematic diagram of lock-out circuitry for use in a lithium ion battery and a charger in accordance with the present invention.

Detailed Description of the Preferred Embodiment

FIG. 1 illustrates a lithium ion battery 100, a charger 200, and a power source 300, such as a conventional alternating current (A/C) outlet. The battery 100 includes a cell arrangement comprising at least one lithium ion cell 104 that is protected, in a conventional manner, from overcharge by a switch, such as a field effect transistor or other type of transistor 102, under the control of an integrated circuit (IC) 107 designed to continuously monitor cell voltage. Another switch, preferably a field effect transistor 103, also protects the cell from overdischarge under control of the IC 107, hereinafter referred to as the protection IC 107. The protection IC 107 can, for instance, be implemented using an application specific integrated circuit (ASIC), such as model number S-8231 manufactured by Seiko. The battery 100 also includes a memory 101, such as an erasable programmable read only memory (EPROM), that contains stored information unique to the particular battery 100. For instance, the memory 101 could store charge instructions, capacity information, maximum and minimum voltage values, etc.

The charger 200 can be coupled to the battery 100 via four battery terminals 109, 110, 111, 112 located on the outside of the battery 100 and four charger terminals 209, 210, 211, 212 located on the outside of the charger 200. Terminal 111 and terminal 211 couple the memory 101 of the battery 100 to a microprocessor 201 included in the charger 200. Terminal 110 and terminal 210 couple a thermistor 108 of the battery 100 to the microprocessor 201 for purposes of monitoring the temperature within the battery 100 in a conventional manner. Terminal 109, terminal 112, terminal 209, and terminal 212 provide a charging current from a regulator 202 within the charger 200 to the cell or cells 104 in accordance with instructions from the microprocessor 201.

According to the present invention, the memory 101, which can be implemented using a model number DS2502 EPROM made by Dallas Semiconductor, includes a latched output port 113 which is coupled to the gate of the overcharge protection transistor 102 so that the transistor 102 is also controlled by the memory 101. The latched output port 113 of the memory 101 is configured to be in a low voltage state under conditions when the battery 100 is removed from electrical contact with a host device (not shown) or with the charger 200. The low voltage at the gate of the

transistor 102 turns off the transistor 102, thereby preventing charging of the cells 104 via the external terminals 109, 112 of the battery 100.

The overcharge protection transistor 102 is also coupled to terminal 112 at its source. The drain of the transistor 102 is coupled to the drain of the overdischarge protection transistor 103. The gate of the transistor 103 is connected to a "DO" port of the protection IC 107, and the source of the transistor 103 is connected to a ground voltage provided by the cells 104. Additionally, the battery 100 includes various other conventional circuit elements, such as capacitors 302-310, resistors 320-326, and zener diodes 330, 332, all of which operate to perform conventional functions in known ways.

Upon insertion of the battery 100 into the charger 200, the microprocessor 201 reads the stored information in the memory 101. This stored information preferably contains unique information, such as a bit pattern or value, indicating to the charger 200 that the battery 100 is "authentic" in the sense that it contains the necessary safety circuitry for safe charging of the lithium cell or cells 104. In response to verifying that the memory 101 includes the proper authentication code in storage, the microprocessor 201 commands the memory 101 to toggle the voltage on the port 113 from a first voltage, e.g., a low state, to a second voltage, e.g., a high state, thereby closing the transistor 102 to enable charging of the cells 104. The microprocessor 201 can, for example, instruct the memory 101 to close the transistor 102 by providing a particular signal, such as a predetermined voltage, at terminal 211. This operation provides a bi-directional lockout function that disables charging of the battery 100 in an unauthorized charger and that also disables charging by the charger 200 of an unauthorized battery, such as occurs when a battery does not include a memory or when a battery memory does not include the proper authorization code.

Also according to the present invention, a host device (not shown) can command the memory 101 to toggle the output port 113 to a high state, thereby closing the transistor 102 to enable charging and discharging of the cell 104 via external contacts 402, 404, 406, 408.

An advantage of the present invention is that bi-directional lock-out circuitry, e.g., the transistor 102, the transistor 103, and the memory 101 in combination with the microprocessor 201, prevents the cell 104 from being overcharged by opening the transistor 102 to prevent current flow when the charger 200 fails to switch the port 113 of the memory 101 to a high state. This can occur either when the charger 200 does not include the appropriate

hardware or software, such as in the microprocessor 201, to read and respond to stored battery information or when the battery 100 does not store the proper authentication code or lacks the memory 101. As a result, the user is doubly protected by the bi-directional lockout feature that prevents both the charging of an unsafe lithium battery and the charging of a safe lithium ion battery by an unsafe charger.

In summary, the bi-directional lockout system as described above requires safety circuitry to be included in both the battery and the charger so that safety concerns with respect to lithium batteries are minimized. Specifically, the battery includes a memory that stores an authentication code indicating to the charger that appropriate safety circuitry is included in the battery. A switch is coupled to and controlled by a latched port of the memory, and defaults to an open circuit condition so that the cells of the battery cannot be charged or discharged. When inserted into the charger, a properly programmed microprocessor within the charger reads the memory to determine whether the correct authentication code is stored. Only when this code is detected does the charger instruct the memory to close the switch so that current can be provided to charge the cells of the battery. In this way, the charger and battery function together to provide redundant safety features.

It will be appreciated by now that there has been provided a device that ensures that both the lithium battery and its charger include safety circuitry necessary to safely charge and discharge the battery.

What is claimed is:

Claims

1. A battery charging system having bi-directional lockout circuitry, the battery charging system comprising:

a battery that stores an authentication code and that includes a cell for providing a voltage at external terminals; and

a charger that instructs the battery to connect the cell to the external terminals in response to verifying the authentication code.

2. The battery charging system of claim 1, wherein the cell includes at least one lithium ion cell.

3. The battery charging system of claim 1, wherein the battery includes a memory for storing the authentication code.

4. The battery charging system of claim 3, wherein the memory additionally stores information unique to the battery.

5. The battery charging system of claim 3, wherein the charger includes a microprocessor for reading the authentication code and for instructing the battery to connect the cell to the external terminals.

6. The battery charging system of claim 3, wherein the battery further comprises a switch coupled between the cell and at least one of the external terminals.

7. The battery charging system of claim 6, wherein the switch is coupled to a latched output port of the memory, and wherein the memory toggles a voltage on the latched output port to open and close the switch.

8. The battery charging system of claim 7, wherein the memory is coupled to a microprocessor of the charger when the battery is inserted into the charger.

9. The battery charging system of claim 7, wherein the switch comprises a transistor having a gate coupled to the latched output port of the memory.

10. The battery charging system of claim 9, wherein the memory provides a first voltage on the latched output port to open the transistor and a second voltage on the latched output port to close the transistor.

11. A battery charging system, comprising:

a lithium ion battery, including:

a memory for storing an authentication code;

at least one lithium ion cell coupled to external terminals of the lithium ion battery; and

a switch coupled between the at least one lithium ion cell and at least one of the external terminals; and

a charger for instructing the lithium ion battery to close the switch in response to verifying the authentication code so that the at least one lithium ion cell can be charged through the external terminals.

12. The battery charging system of claim 11, wherein the memory comprises an erasable programmable read only memory.

13. The battery charging system of claim 11, wherein the memory stores information unique to the lithium ion battery.

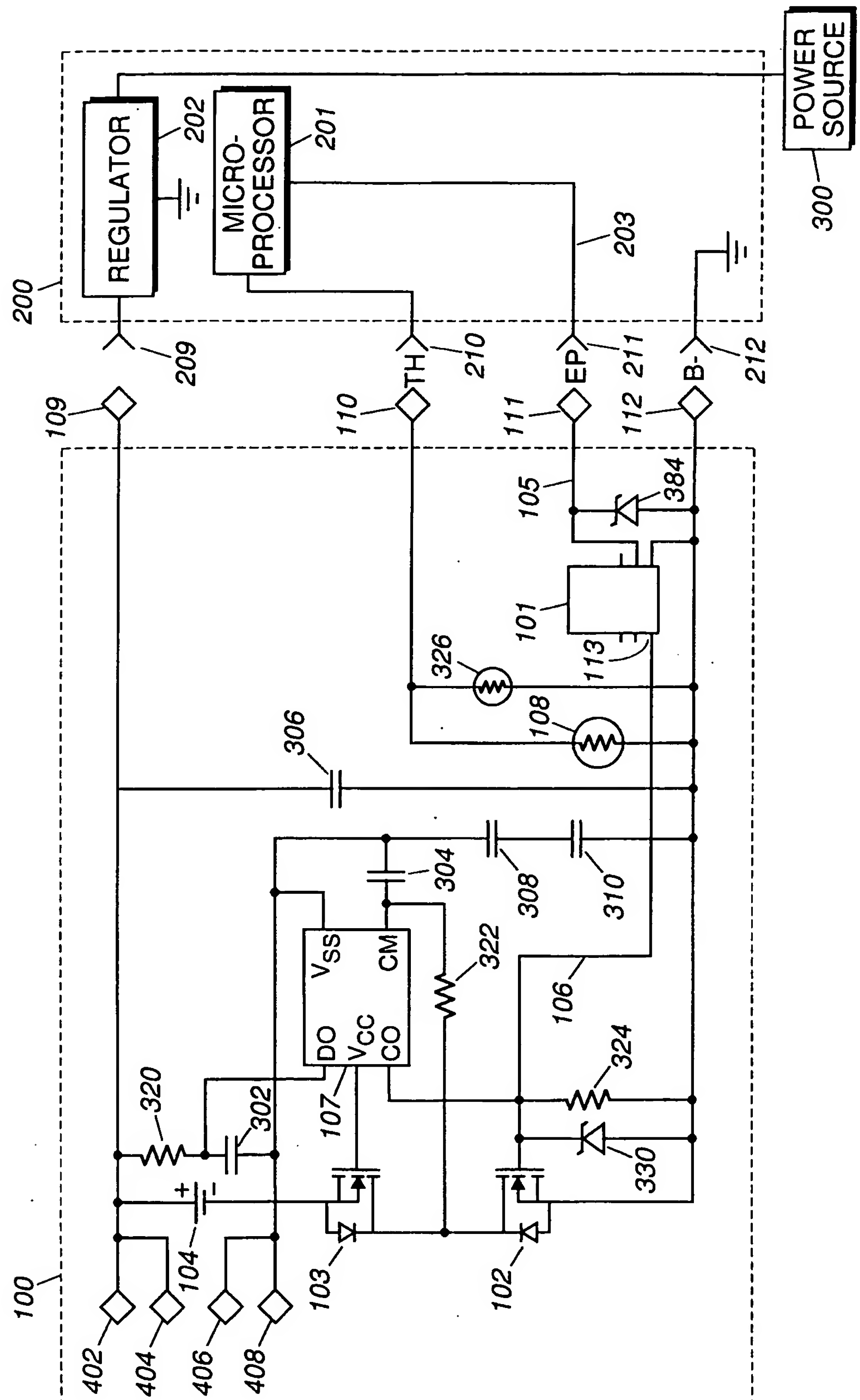
14. The battery charging system of claim 11, wherein the charger includes a microprocessor for reading the authentication code and for instructing the lithium ion battery to close the switch.

15. The battery charging system of claim 11, wherein the switch is coupled to a latched output port of the memory, and wherein the memory toggles a voltage on the latched output port to open and close the switch.

16. The battery charging system of claim 15, wherein the memory is coupled to a microprocessor included in the charger when the lithium ion battery is inserted into the charger.

17. The battery charging system of claim 15, wherein the switch comprises a transistor having a gate coupled to the latched output port of the memory.

18. The battery charging system of claim 17, wherein the memory provides a first voltage on the latched output port to open the transistor and a second voltage on the latched output port to close the transistor.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